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ently for the pleasure and excitement it gives, rather than to procure for himself food. This insurmountable passion he gratifies without the least fear of plunging from the great height to which he soars, whizzing through the air swifter than the torrent into which he rushes, making the water foam around him. Night often overtakes him in the heat of the pursuit, and not until the last ray of light has disappeared in the west does he forsake the chase. His day's hunt over, he perches upon some tree bordering upon the shore of the river or coast of the sea, and remains through the night. He is awakened by the freshness of the morning air and the roar of the long rolling waves when their irresistible columns meet the shore and are broken. He rises and shakes the dews of night from his feathers, gives them a few touches with his bill, and again goes forth, rejoicing in his strength, over waters filled with a superabundance of food.

THE PARASITES OF THE HONEY-BEE.

BY A. S. PACKARD, JR.

VERY few bee-keepers are probably aware how many insect parasites infest the Honey-bee. In our own literature we hear almost nothing of this subject, but in Europe much has been written on bee parasites. From Dr. Edward Assmuss' little work on "the Parasites of the Honey-bee," we glean many of the facts now presented, and which cannot fail to interest the general reader as well as the owner of bees.

The study of the habits of animal parasites has of late gained much attention among naturalists, and both the honey and wild bees afford good examples of the singular relation between the host and the parasites which live upon it. Among insects generally, there are certain species which devour the contents of the egg of the victim. Others, and this is the most common mode of parasitism, attack the insect in its larva state; others in the pupa state, and still others in the perfect, or imago state. Dr. Leidy has shown that of the wood-devouring species, a beetle, *Passalus cornutus*, and some *Myriapods*, or "thousand legs," are, in some cases, tenanted by myriads of microscopic plants and worms which luxuriate in the alimentary canal, while the "caterpillar-fungus" attacks sickly caterpillars, filling out their bodies, and sending out shoots into the air, so that the insect looks as if transformed into a vegetable.

The Ichneumon flies, of which there are undoubtedly several thousand species in this country, are the most common insect parasites. Their habits are noticed in the NATURALIST, Vol. I, p. 81. Next to these are the different species of *Tachina* and its allied genera. These, like Ichneumons, live in the bodies of their hosts, consuming the fatty parts, and finishing their transformations just as the exhausted host is ready to die, issue from their bodies as flies, closely resembling the common house-fly.

An insect, allied to the Tachina, has been found in Europe to be the most formidable foe of the hive-bee, sometimes producing the well-known disease called "foul-brood," which is analogous to the typhus fever of man.

This fly, belonging to the genus *Phora* (Plate 4, fig. 1, *Phora incrassata*; Fig. 2, larva; Fig. 3, *puparium*), is a small insect about one line and a half long, and found in Europe during the summer and autumn flying slowly about flowers and windows, and in the vicinity of bee-hives. Its white, transparent larva is cylindrical, a little pointed before, but broader behind. The head is small and rounded, with short three-jointed antennæ, and at the posterior end of the body are several slender spines. The *puparium*, or pupa-case, inclosing the delicate chrysalis, is oval, consisting of eight segments, flattened above and with two large spines near the head, and four on the extremity of the body.

When impelled by instinct to provide for the continuance of its species, the Phora enters the bee-hive and gains admission to a cell, when it bores with its ovipositor through the skin of the bee-larva, laying its long oval egg in a horizontal position just under the skin. The embryo of the Phora is already well developed, so that in three hours after the egg is inserted in the body of its unsuspecting and helpless host, the embryo is nearly ready to hatch. In about two hours more it actually breaks off the larger end of the egg-shell and at once begins to eat the fatty tissues of its victim, its posterior half still remaining in the shell. In an hour more, it leaves the egg entirely and buries itself completely in the fatty portion of the young bee.

The maggot moults three times. In twelve hours after the last moult it turns around with its head towards the posterior end of the body of its host, and in another twelve hours, having become full-fed, it bores through the skin of the young, eats its way through the brood-covering of the cell and falls to the bottom of the hive, when it changes to a pupa in the dust and dirt, or else it creeps out of the door and transforms in the earth. Twelve days after, the fly appears.

The young bee, emaciated and enfeebled by the attacks of its ravenous parasite, dies, and its decaying body fills the bottom of the cell with a slimy foul-smelling mass, called "foul-brood." This gives rise to a miasma which poisons the neighboring brood, until the contagion (for the disease is analogous to typhus, jail, or ship-fever) spreads through the whole hive, unless promptly checked by removing the cause and thoroughly cleansing the hive.

Foul-brood sometimes attacks our American hives, and, though the cause may not be known, yet from the hints given above we hope to have the history of our species of Phora cleared up, should our disease be found to be sometimes due to the attacks of such a parasite fly.

We figure the Bee-louse of Europe (Plate 4, fig. 4, *Braula* *cœca* Nitsch), which is a singular wingless spider-like fly, allied to the wingless Sheep-tick (*Melophagus*), the wingless Bat-tick (*Nycteribia*), and the winged Horse-fly (*Hippobosca*). The body is divided into two regions, like the spider. The head is very large, without eyes or ocelli (simple eyes), and the ovate hind-body consists of five segments, and is covered with stiff hairs. It is one-half to two-thirds of a line long. This spider-fly is "pupiparous," that is, the young, of which only a very few are produced, is not born until it has, or is just about to, assume the pupa state. The larva (Plate 4, Fig. 5) is oval, eleven-jointed, and white in color. The very day it is hatched it sheds its skin and changes to an oval puparium of a dark-brown color.

Its habits resemble that of the flea. Indeed, should we compress its body strongly, it would bear a striking resemblance to that insect. It is evidently a connecting link between the flea, and the two-winged flies. Like the former it lives and brings forth its young on the body of its host, and draws its food from its host by plunging its stout beak into the skin of the bee.

It has not been noticed in this country, but is liable to be imported on the bodies of Italian bees. Generally, one or two of the Braulas may, on close examination, be detected on the body of the bee; sometimes the poor bees are loaded down by as many as a hundred of these hungry bloodsuckers. Assmuss recommends rubbing them off with a feather, as the bee goes in and out of the door of its hive.

Among the beetles are a few forms occasionally found in bees' nests and also parasitic on the body of the bee. *Trichodes apiarius* Linn. (Plate 4, fig. 6, fig. 6 *a*, larva; fig. 6 *b*, pupa, front view) has long been known in Europe to attack the young bees. In its perfect, or beetle, state it is found on flowers, like our *Trichodes Nuttallii*, which is commonly found on the Spiræa in August, and which may yet prove to enter our bee-hives. The larva devours the brood, but with the modern hive its ravages may be readily detected.

The Oil-beetle, *Meloë angusticollis* Say (Plate 4, fig. 7, male, differing from the female by having the antennæ as if twisted into a knot; Fig. 8, the active larva found on the body of the bee), is a large dark-blue insect found crawling in the grass in the vicinity of the nests of Andrena and Halictus and other wild bees in May, and again in August and September. The eggs are laid in a mass covered with earth at the root of some plant. During April and early in May, when the willows are in blossom, we have found the young recently hatched larvæ in considerable abundance creeping briskly over the bees, or with their heads plunged between the segments of the body, greedily sucking in the juices of their host. Those that we saw occurred on the humble-bee, Halictus and Andrena, and various flies (Syrphus and Muscidæ), and there is no reason why they should not infest the honey-bee which frequent similar flowers, as they actually are known to do in Europe. These larvæ are probably hatched out near where the bees hybernate so as to creep into their bodies before they fly in the spring, as it would be impossible for them to crawl up a willow tree ten feet high or more, their feet being solely adapted for climbing over the hairy body of the bee, which they do not leave until about to undergo their strange and unusual transformations.

In Europe, Assmuss states that on being brought into the nest by the bee, they leave the bee and devour the eggs in the bee-cells, and then attack the bee-bread. When full-fed and ready to pass through their transformations to attain the bee state, instead of at once assuming the pupa and imago state, as in the Trichodes represented above, they pass through a *hyper-metamorphosis*, as Fabre, a French naturalist, calls it. In other words, the changes in form which are preparatory to assuming the pupa and imago states are here more marked and almost coequal with the larva and pupa states, so that the Meloë, instead of passing through three states (the egg, larva, and pupa), in reality passes through these and two others in addition, which are intermediate. The whole subject of the metamorphosis of this beetle needs revision, but Fabre states that the larva, soon after entering the nest of its host, changes its skin and assumes a second larva form (Plate 4, fig. 9), which somewhat resembles the larva of the Goldsmith beetle (P. 187, fig. 2). Newport, who with Siebold has carefully described the metamorphoses of Meloë, does not mention this stage in its development, which he calls "pseudo-chrysalis." It is motionless; the head is mask-like, without movable appendages, and the feet are represented by six tubercles. This is more properly speaking the semi-pupa, and the mature pupa grows beneath its mask-like form, which is finally moulted. This form, however, according to Fabre, changes its skin and turns into a third larva-form (Plate 4, fig. 10, from Newport). After some time it assumes its true pupa form (Plate 4, fig. 11, from Newport), and finally moults this skin to appear as a beetle (Plate 4, fig. 7).

Fabre has also, in a lively and well-written account, given a history of *Sitaris*, an European beetle, somewhat resembling Meloë. He states that Sitaris lays its eggs near the entrance of bees' nests, and at the very moment that the bee lays her egg in the honey-cell the flattened ovate Sitaris larva drops from the body of the bee upon which it has been living, and feasts upon the contents of the freshly laid egg. After eating this delicate morsel it devours the honey in the cell of the bee and changes into a white cylindrical, nearly footless grub, and after it is full-fed, and has assumed a supposed "pupa" state, the skin, without bursting, incloses a kind of hard "pupa" skin, which is very similar in outline to the former larva, within whose skin is found a whitish larva which directly changes into the true pupa. In a succeeding state this pupa in the ordinary way changes to a beetle which belongs to the same group of Coleoptera as Meloë. We cannot but think, from observations made on the humble-bee, the wasp, two species of moths, and several other insects, that this "hyper-metamorphosis" is the normal mode of insect metamorphosis, and that the changes of these insects, made beneath the skin of the mature larva before assuming the pupa state, are almost as remarkable, though less easily observed, as those of Meloë and Sitaris. Several other beetles allied to Meloë are known to be parasitic on wild bees, though the accounts of them are fragmentary.

The history of *Stylops*, a beetle allied to Meloë, is no less strange than that of Meloë, and is in some respects still more interesting. On June 18th I captured an *Andrena vicina* (figured on p. 397 of the first volume of the NATURALIST) which had been "stylopized". On looking at my capture I saw a pale reddish-brown triangular mark on the bee's abdomen; this was the flattened head and thorax of a female Stylops (Plate 4, fig. 12, position of the female of Stylops, seen in profile in the abdomen of the bee; Fig. 13, the female seen from above. The head and thorax is soldered into a single flattened mass, the baggy hind-body being greatly enlarged like that of the gravid female of the white ant, *Termes*, and consisting of nine segments).

On carefully drawing out the whole body which is very extensible, soft, and baggy, and examining it under a high power of the microscope, we saw multitudes, at least several hundred, of very minute larvæ (Plate 5, fig. 6, as seen from above, and showing the alimentary canal ending in a blind sac; Fig. 6 *a*, side view), like particles of dust to the naked eye, issuing in every direction from the body of the parent now torn open in places, though most of them made their exit through an opening on the under side of the head-thorax. The Stylops, being hatched out while still in the body of the parent, is therefore viviparous. She probably never lays eggs.

On the last of April, when the Mezereon was in blossom, I caught the singular-looking male, *Stylops Childreni* Gray (Plate 4, fig. 14; *a*, side view; it is about one-fourth of an inch long), which was as unlike its partner as possible. I laid it under a tumbler, when the delicate insect flew and tumbled about till it died of exhaustion in a few hours.

It appears, then, that the larvæ are hatched during the middle or last of June from eggs fertilized in April. The larvæ then crawl out on to the body of the bee, on which they are transported to the nest, when they enter, according to Peck's observations, the body of the larva, on whose fatty parts they feed. Previous to changing to a pupa, the larva lives with its head turned towards that of its host, but before assuming the perfect state (which they do in the late summer or autumn) they must reverse their position. The female protrudes the front part of its body between the segments of the abdomen of her host, as represented in our figure. This change, Newport thinks, takes place after the bee-host has undergone its metamorphoses, though the bee does not leave her earthen cells until the following spring. While the male Stylops deserts its host, his wingless partner is imprisoned during her whole life within her host, and dies immediately after giving birth to her myriad (for Newport thinks she produces over 2000 young) offspring.

Xenos Peckii, an allied insect, was discovered by Dr. Peck to be parasitic in the body of wasps, and there are now known to be several species of this small but curious family, *Stylopidæ*, which are known to live parasitically on the bodies of our wild bees and wasps. The presence of these parasites which live on the fatty parts finally exhausts the host, so that the sterile female bee dies prematurely.

As in the higher animals bees are afflicted with parasitic worms which induce disease and sometimes death. The well-known hair-worm, Gordius, is an insect-parasite. The adult form is about the size of a thick horse-hair, and is seen in moist soil and in pools. It lays, according to Dr. Leidy, "millions of eggs connected together in long cords." The microscopic tadpole-shaped young penetrate into the bodies of insects frequenting damp localities. Fairly esconced within the body of their unsuspecting host, they luxuriate on its fatty tissues, and pass through their metamorphoses into the adult form, when they desert their living house and take to the water to lay their eggs. In Europe, Siebold has described *Gordius subbifurcus* which infests the drones of the honey-bee, and also other insects. Professor Siebold has also described *Mermis albicans*, which is a similar kind of hair-worm, from two to five inches long, and whitish in color. This worm is also found, strangely enough, only in the drones, though it is the workers which frequent watery places to appease their thirst.

Thousands of insects are carried off yearly by parasitic fungi. The ravages of the Muscardine, caused by a minute fungus (*Botrytris Bassiana* Balsamo), has threatened the extinction of silk culture in Europe. Dr. Leidy mentions a fungus which must annually carry off myriads of the Seventeen Year Locust. A somewhat similar fungus, *Mucor mellitophorus* (Plate 4, fig, 15), infests bees, filling the stomach with microscopic colorless spores, so as to greatly weaken the insect.

As there is a probability that many insects, parasitic on the wild bees, may sooner or later afflict the honey-bee, and also to farther illustrate the complex nature of insect parasitism, we will for a moment look at some other bee-parasites.

Among the numerous insects preying in some way upon the Humble-bee are to be found other species of bees and moths, flies and beetles. Insect parasites often imitate their host: *Apathus* (Plate 5, fig. 1, *A. Ashtoni*) can scarcely be distinguished from its host, and yet it lives cuckoo-like in the cells of the humble-bee, though we know not yet how injurious it really is. Then there is the *Conops* and *Volucella*, the former of which lives like Tachina and Phora within the bee's body, while the latter devours the brood. The young (Plate 5, figs. 5, 5*a*) of another fly allied to Anthomyia, of which the Onion-fly is an example, is also not infrequently met with. A small beetle (Plate 5, fig. 4, *Antherophagus* *ochraceus*) is a common inmate of humble-bees' nests, and probably feeds upon the wax and pollen. We have also found several larvæ (Plate 4, fig. 16) of a beetle of which we do not know the adult form. Of similar habits is probably a small moth (*Nephopteryx Edmandsii*, Plate 5, figs. 2, 2*a*, larva; fig. 2*b*, chrysalis, or pupa) which undoubtedly feeds upon the waxen walls of the bee-cells, and thus, like the attacks of the common bee-moth (*Galleria cereana*), whose habits are so well known as not to detain us, must prove very prejudicial to the well-being of the colony. This moth is in turn infested by an Ichneumon-fly (*Microgaster nephoptericis*, Plate 5, figs. 3, 3*a*) which must destroy many of them.

The figures of the early stages of a minute ichneumon represented on the same plate (Fig. 7, larva, and 7*a*, pupa, of *Anthophorabia megachilis*) which is parasitic on Megachile, the Leaf-cutter bee, illustrates the transformations of the Ichneumon-flies, the smallest species of which yet known (and we believe the smallest insect known at all) is the *Pteratomus Putnami*, or "winged-atom," which is only one-ninetieth of an inch in length, and is parasitic on Anthophorabia, itself a parasite. A species of mite (Plate 5, figs. 9, 9*a*, the same seen from beneath) is always to be found in humble-bees' nests, but it is not thought to be specially obnoxious to the bees themselves, though several species of mites (*Gamasus*, etc.) are known to be parasitic on insects.

For a proper study of our bees and wasps, we should collect their nests from the last of May until late in the autumn. We should watch for the different broods and collect the larva, pupa, and adult of both sexes, as well as the workers. The cells containing the young, with whatever parasites may be found on them, may be placed in alcohol, while the mature bees may be pinned. The simplest method of collecting the nests of humble-bees is to visit them before sunrise or after sunset, when the bees are in the nest, and we can secure the whole colony. The bees can be picked up with

Fig. 1.

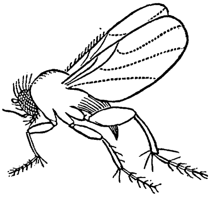


Fig. 3.

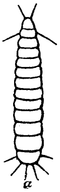
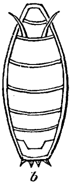


Fig. 2.



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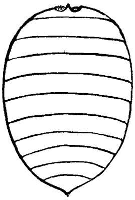

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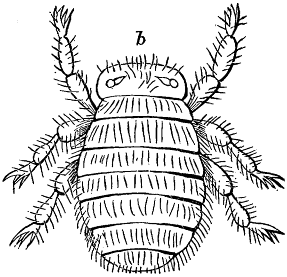

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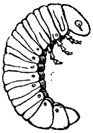


Fig. 8.

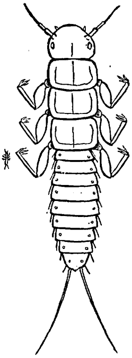


Fig. 11.

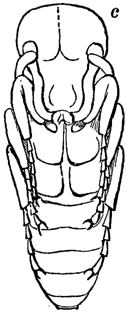


Fig. 7.

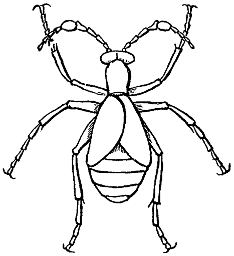


Fig. 10.

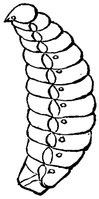


Fig. 6.

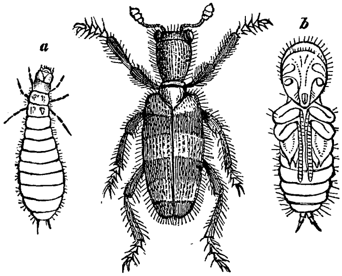


Fig. 14.

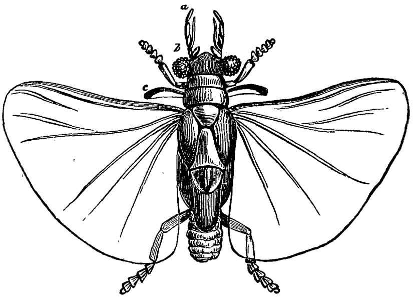


Fig. 14 *a*.

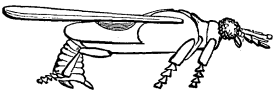
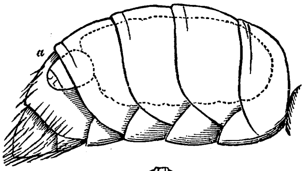


Fig. 12.



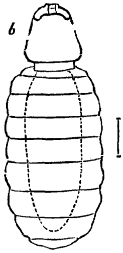


Fig. 13.

Fig. 16.

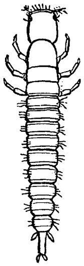
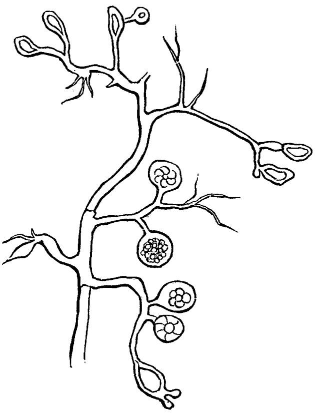
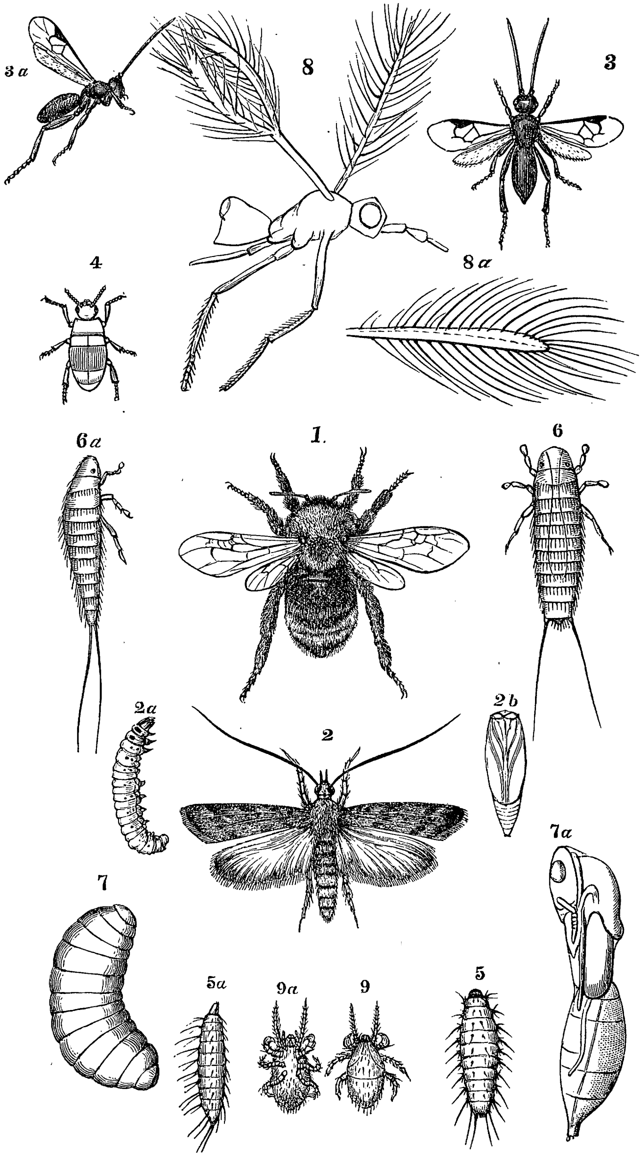


Fig. 15.



PACKARD ON THE PARASITES OF THE HONEY-BEE.



PACKARD ON THE PARASITES OF THE HONEY-BEE.

forceps as they emerge from the nest, or caught with the net and then pinned. Refractory colonies may be easily quelled by pouring in ether or chloroform, or burning sulphur at the aperture, as is the best method of procedure with wasp's nests.

The solitary species, besides boring in the earth like Andrena and Halictus, whose habits have been described in the first volume of the NATURALIST, also bore in the stems of different plants, such as the elder, syringa, raspberry, and blackberry. Nearly fifty species of insects, mostly hymenoptera, are known in France to burrow in the stems of the blackberry alone! Now is the time to look for their burrows in the dead branches. Their presence is usually detected by an old hole at the end of a broken branch. The writer would be greatly obliged for material to aid him in the study of our bees and wasps, and would take pleasure in corresponding with those interested in the study of their habits, and would be very grateful for specimens of the young in alcohol, their parasites and nests.

REVIEWS.

VOLCANIC ROCKS.*—The author of this interesting memoir classifies volcanic rocks in five orders. The first order consists of Rhyolite with three families, Nevadite or granitic-rhyolite, Liparite or porphyritic-rhyolite, and Rhyolite proper or Lithodic and Hyaline-rhyolite. The second is Trachyte with two families, Samidin-trachyte and Oligoclase-trachyte. The third is Propylite with three families, Quartzose-propylite, Hornblendic-propylite, and Augitic-propylite. The fourth is Andesite with two families, Hornblendic-andesite, and Augitic-andesite. The fifth order is Basalt with three families, Dolerite, Basalt, and Leucitophyte.

The author confines himself in this classification to volcanic rocks of Tertiary and Post-tertiary age, which he subdivides into "massive eruptions" and "volcanic eruptions." The origin of massive eruptions is

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* Principles of the Natural System of Volcanic Rocks. By F. Baron Richtofen, Dr. Phil. Memoirs presented to the California Academy of Science, Vol. I, Part 2. May 6, 1867. pp. 4, 94.